DEFENCE R&D DÉFENSE

Airborne Surveillance Concepts Post 2010: Interim Report

Steven J. Hughes
Defence Research Establishment Ottawa

DEFENCE RESEARCH ESTABLISHMENT OTTAWA

TECHNICAL MEMORANDUM
DREO TM 1999-126
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Project
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ABSTRACT

The *Airborne Surveillance Concepts 2010* project is sponsored by the Director, Science and Technology Air, and supported by the Thrust Leader, Airborne Surveillance. The purpose of the project is to propose advanced surveillance concepts to contribute to Air Force operations after the year 2010. The aim of the project is to anticipate the availability of future technologies to support long-term planning by the Canadian Forces, to stimulate discussion of new concepts of operations and doctrine, and to provide guidance for activities within the Defence Research and Development Branch (DRDB). This interim report reviews government policy, departmental guidance, and related initiatives in allied countries. It discusses the future surveillance needs of the Canadian Forces and presents a concept airborne surveillance system to address these needs. The potential role of the Defence Research and Development Branch is discussed in realizing the objectives of the system. Future work includes consultation with client groups in the Canadian Forces and with DRDB staff to validate the future surveillance needs and to enhance the capabilities of the concept airborne surveillance system.

RÉSUMÉ

Concepts de systèmes de surveillance de bord 2010 est un projet qui est parrainé par le Directeur - Sciences et technologie (Air) et qui a pour objet de proposer des concepts de surveillance perfectionnés pour contribuer aux opérations des Forces aériennes passé l'an 2010. Ce projet a pour but d'anticiper la disponibilité de technologies futures à l'appui de la planification à long terme par les Forces canadiennes, de stimuler l'étude de nouveaux concepts d'opérations et de doctrine et d'assurer l'orientation des activités de la Direction de recherches et de développement pour la défense (DRDD). Le présent rapport d'étape examine la politique gouvernementale, l'orientation du Ministère et des initiatives connexes aux pays alliés. Il traite des besoins de surveillance futurs des Forces canadiennes et présente un système de surveillance de bord conceptuel pour répondre à ces besoins. De plus, il étudie le rôle potentiel de la Direction de recherches et de développement pour la défense dans la réalisation des objectifs du système. Le travail futur comprendra la consultation de groupes de clients au sein des Forces canadiennes et du personnel de la DRDD pour valider les besoins de surveillance futurs et pour améliorer les capacités du système de surveillance de bord conceptuel.

EXECUTIVE SUMMARY

The effective use of information and information technologies, and the ability to employ and rapidly exploit technological change will be the dominant aspects of warfare in the next century. Surveillance systems will contribute significantly to the successful conduct of future warfare by providing essential information to command and control systems.

This Technical Memorandum is an interim report that is part of the *Airborne Surveillance Concepts 2010* project, sponsored by the Director Science and Technology Air and supported by the Thrust Leader, Airborne Surveillance. The aim of the project is to propose advanced surveillance concepts to contribute to Air Force operations after the year 2010. The report reviews government policy, departmental guidance, and related initiatives in allied countries. It discusses the future surveillance needs of the Canadian Forces, presents a concept airborne surveillance system, and discusses the potential role of the Defence Research and Development Branch in realizing the objectives of the system.

The future surveillance needs are discussed with respect to complete mission scenarios, and are not tied to specific platforms, sensors, or systems. The mission scenarios are derived from the most recent Defence Planning Guidance and the draft Departmental Force Planning Scenarios.

A concept surveillance system is developed based on the future surveillance needs and the mission scenarios. This system is composed of surveillance sources, surveillance users, and disseminators of surveillance information, all connected to one another by means of high capacity data links and using intelligent assistant software to help the operators.

The role of the Defence Research and Development Branch is discussed with respect to a number of activities, including enhancing interoperability, improving the performance of individual sensors, developing techniques for multi-sensor data fusion, developing techniques for target recognition and feature extraction, developing techniques to ensure the integrity of communication links, and developing advanced human-machine interfaces and training programs to aid the operators.

Future work will include consultation with client groups in the Canadian Forces to validate the future surveillance needs and to enhance the capabilities of the concept surveillance system. Consultation within the Defence Research and Development Branch will further define the role of the Branch in satisfying these future needs and in realizing the objectives of the concept surveillance system.

Hughes, Steven J., Future Concepts of Airborne Surveillance: Interim Report. Defence Research Establishment Ottawa, DREO TM 1999-126. December 1999.

SOMMAIRE

L'utilisation efficace de l'information et des technologies de l'information et la capacité à utiliser et à exploiter rapidement les changements technologiques seront les aspects prédominants de la conduite de la guerre au cours du prochain siècle. Les systèmes de surveillance contribueront grandement à la conduite réussie de la guerre future en fournissant de l'information essentielle aux systèmes de commandement et de contrôle.

Le présent document technique est un rapport d'étape qui fait partie du projet *Concepts de systèmes de surveillance de bord 2010*, parrainé par le Directeur - Sciences et technologie (Air), qui a pour but de proposer des concepts de surveillance perfectionnés pour contribuer aux opérations des Forces aériennes passé l'an 2010. Le rapport examine la politique gouvernementale, l'orientation du Ministère et des initiatives connexes aux pays alliés. Il traite des besoins de surveillance futurs des Forces canadiennes, présente un système de surveillance de bord conceptuel et étudie le rôle potentiel de la Direction de recherches et de développement pour la défense dans la réalisation des objectifs du système.

Les besoins de surveillance futurs sont étudiés en rapport avec des scénarios de mission complets et ne sont pas liés à des plates-formes, des capteurs ou des systèmes particuliers. Les scénarios de mission sont dérivés du Guide de planification de la Défense et de l'ébauche des scénarios de planification de la force du Ministère.

Un système de surveillance conceptuel est élaboré en fonction des besoins de surveillance futurs et des scénarios de mission. Ce système comprend des sources de surveillance, des utilisateurs de la surveillance et des diffuseurs de l'information de surveillance, tous reliés ensemble au moyen de liaisons de données à grande capacité et faisant appel à un logiciel d'agent intelligent pour aider les opérateurs.

Le rôle de la Direction de recherches et de développement pour la défense est étudié à l'égard de l'amélioration de l'interfonctionnement, de l'amélioration des performances des capteurs individuels, de l'élaboration de techniques de fusion des données de capteurs multiples, de l'élaboration de techniques de reconnaissance des cibles et d'extraction de leurs caractéristiques, de l'élaboration de techniques pour assurer l'intégrité des liaisons de communication et de l'élaboration d'interfaces homme-machine perfectionnées et de programmes de formation pour aider les opérateurs.

Le travail futur comprendra la consultation de groupes de clients au sein des Forces canadiennes pour valider les besoins de surveillance futurs et pour améliorer les capacités du système de surveillance conceptuel. La consultation de la Direction de recherches et de développement pour la défense permettra de préciser le rôle de la Direction dans la satisfaction de ces besoins futurs et dans la réalisation des objectifs du système de surveillance conceptuel.

Hughes, Steven J., Concepts de systèmes de surveillance de bord 2010: rapport d'étape. Le Centre de recherches pour la défence Ottawa, DREO TM 1999-126. décembre 1999. (en anglais)

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1.0 INTRODUCTION

The effective use of information and information technologies, and the ability to employ and rapidly exploit technological change will be the dominant aspects of warfare in the next century [1]. Surveillance systems will contribute significantly to the successful conduct of future warfare by providing essential information to command and control systems.

Space-based, airborne, and ground-based surveillance systems have complementary attributes. Generally speaking, space-based systems offer the widest coverage, but with potentially long revisit times; ground-based systems might offer full-time coverage, but are normally limited to operation within a fixed geographical area. In contrast, airborne systems offer the potential for long-term full-time coverage and wide area surveillance, with the additional flexibility of mobility, resource tasking, and vehicle recovery.

This Technical Memorandum is an interim report for the *Airborne Surveillance Concepts 2010* project, which is sponsored by the Director Science and Technology Air to propose advanced surveillance concepts to contribute to Air Force operations after the year 2010.

Section 2.0 reviews a number of reference documents to situate airborne surveillance capabilities within the larger context of overall departmental surveillance capabilities. The documents describe government defence policy, strategic departmental guidance, and doctrine.

Section 3.0 describes the initiatives underway in the United States and in NATO that are relevant to future concepts of airborne surveillance. These initiatives support the concept of integrated and interoperable surveillance systems to support future warfare.

Section 4.0 discusses the future surveillance needs of the Canadian Forces. These needs are based on strategic departmental guidance and complete mission scenarios; they are not tied to specific platforms, sensors, or systems.

Section 5.0 presents a concept airborne surveillance system based on the future surveillance needs and mission scenarios. This system is composed of surveillance sources, surveillance users, and disseminators of surveillance information. All system components are connected to one another by means of high capacity data links, and use intelligent assistant software to help the operators cope with the overwhelming quantity of data that will be available.

Section 6.0 discusses the role of the Defence Research and Development Branch (DRDB) to enhance interoperability, to improve the performance of individual sensors, to develop techniques for multi-sensor data fusion, to develop techniques for target recognition and feature extraction, to develop techniques to ensure the integrity of communication links, and to develop advanced human-machine interfaces and training programs to aid the operator.

Section 7.0 discusses future work that will include consulting with client groups in the Canadian Forces and with DRDB scientists to enhance the capabilities and realize the objectives of the concept surveillance system.

The summary and conclusions are presented in Section 8.0.

2.0 REFERENCE DOCUMENTS

This section reviews government policy, strategic departmental guidance, and aerospace doctrine in the context of surveillance missions and capabilities. The intention is to situate airborne surveillance capabilities within the larger context of overall departmental surveillance capabilities.

2.1 National Defence Policy

The 1994 White Paper on Defence [2] is the most recent statement of government direction regarding the obligations and undertakings of the Department of National Defence and the Canadian Forces. The White Paper identifies five objectives relevant to surveillance capability requirements:

1. To maintain and exercise the required military capabilities to provide surveillance and control of Canadian territory, airspace, and maritime approaches;

2. To assist Other Government Departments (OGDs) in the surveillance and control of Canadian territory, airspace, and maritime areas of jurisdiction to attain national objectives in such areas as environmental protection, search and rescue, disaster relief, drug interdiction, and fisheries protection;

3. To maintain the ability to operate effectively at sea, on land, and in the air with the military forces of the United States in defending the northern half of the western hemisphere;

4. To cooperate with the United States in the surveillance and control of North American airspace; and

5. To participate in multilateral operations anywhere in the world under UN auspices, or in the defence of a NATO member state.

2.2 Strategic Departmental Guidance

Strategic departmental guidance is found in the Defence Planning Guidance [3] and the Departmental Force Planning Scenarios [4].

2.2.1 Defence Planning Guidance

The Defence Planning Guidance (DPG 99) [3] translates government direction in the Defence White Paper into a Defence Services Program that delivers capable armed forces for Canada. It also provides strategic guidance for a five-year horizon.

The DPG defines three broad Defence Missions to realize the overall mission of the Department of National Defence and the Canadian Forces, which is "to defend Canada and Canadian interests and values while contributing to international peace and security." The three Defence Missions are:

1. **Defending Canada**: protecting Canada's national territory and areas of jurisdiction; helping civil authorities protect and sustain national interests; ensuring an appropriate level of emergency preparedness across Canada; and assisting in national emergencies;

2. **Defending North America:** protecting the Canadian approaches to the continent in partnership with the United states, particularly through NORAD; promoting Arctic security; and pursuing opportunities for defence cooperation with the US in other areas; and

3. **Contributing to International Security:** participating in a full range of multilateral operations through the UN, NATO, other regional organizations and coalitions of like-minded countries; supporting humanitarian relief efforts and restoration of conflict-devastated areas; and participating in arms control and other confidence-building measures.

2.2.2 Departmental Force Planning Scenarios

The Departmental Force Planning Scenarios [4] are a set of eleven generic missions designed to be illustrative of the various tasks the Canadian Forces could be called upon to perform. The scenarios are based upon defence policy, are set at the strategic level, and apply to the Canadian Forces as a whole. The scenarios encompass the entire spectrum of conflict that would involve military operations of some type.

The draft Departmental Force Planning Scenarios are described briefly below, in order of decreasing priority [5]:

1. **(Scenario 9) Peace Support Operations (UN Chapter 7).** Upon request, the Canadian Forces will participate as part of an international coalition force in peacemaking operations under the auspices of Chapter 7 of the United Nations Charter.

2. **(Scenario 4) Surveillance and Control of Canadian Territory and Approaches.** The Canadian Forces are committed to protect Canada and its citizens from challenges to their security. This is achieved in part by maintaining Canadian sovereignty. Maintaining sovereignty includes the provision of peacetime surveillance and control, and securing our borders against illegal activities.

3. **(Scenario 11) Collective Defence.** The Canadian Forces are committed to contribute to international security through Canada's participation in the United Nations (UN), the North Atlantic Treaty Organization (NATO), and the Organization for Security and Cooperation in Europe (OSCE).

4. **(Scenario 10) Defence of Canadian and US Territory.** The Canadian Forces, in coalition with the Armed Forces of the United States, are committed under the Canada-US Basic Security Plan to assign specified forces to the defence of North America.

5. **(Scenario 1) Search and Rescue in Canada.** The Canadian Forces are responsible for air search and rescue, provide assistance to the Coast Guard for marine search and rescue, and assist local authorities for land search and rescue.

6. **(Scenario 6) Peace Support Operations (UN Chapter 6).** Upon request, the Canadian Forces participate in peacekeeping operations under the auspices of Chapter 6 of the United Nations Charter.

7. **(Scenario 8) National Sovereignty and Interests Enforcement.** Upon request, the Canadian Forces assist civil authorities to protect Canada's natural resources from illegal exploitation.

8. **(Scenario 2) Disaster Relief in Canada.** Upon request, the Canadian Forces assist civil authorities to provide relief from both natural and man-made disasters.

9. **(Scenario 7) Aid of the Civil Power.** Upon request, the Canadian Forces assist civil authorities to maintain or restore law and order where it is beyond the power of the civil authorities to do so.

10. **(Scenario 3) International Humanitarian Assistance.** Upon request, the Canadian Forces provide international humanitarian assistance by ensuring a safe environment for the protection of refugees,

delivering food and medical services, and providing essential services in countries where civil society has collapsed.

11. **(Scenario 5) Evacuation of Canadians Overseas.** Upon request, the Canadian Forces assist the Department of Foreign Affairs and International Trade (DFAIT) in the protection and evacuation of Canadians from areas threatened by imminent conflict.

2.3 Aerospace Doctrine

Canadian aerospace doctrine, which is enunciated in the publication *Out of the Sun* [6], defines Aerospace Surveillance and Reconnaissance (ASR) as one of seven Supporting Air Operations. ASR operations involve the collection of information on the resources and activities of an adversary or potential adversary by airborne, ground-based, and space-based sensors. In general, many of the same assets are used for both reconnaissance and surveillance.

A critical function of ASR systems is to detect abnormalities or changes in the behaviour of actual or potential adversaries. To do this successfully in war, it is essential to have a dynamic ASR program in peace. *Out of the Sun* defines three primary roles for ASR operations:

1. **Strategic ASR.** Strategic ASR operations collect the information necessary for the formulation of policy and military plans at national and multinational levels;

2. **Tactical ASR.** Tactical ASR operations collect information on an adversary, the weather and geographical features required for the planning and conduct of combat operations, and provide information about targets within defined areas; and

3. **Target Acquisition.** Target acquisition involves the detection, identification and location of targets in sufficient detail and in the appropriate time-scale to permit the effective employment of weapons.

3.0 DIRECTIONS OF ALLIED NATIONS

To satisfy the requirements of the Defence White Paper and the Defence Planning Guidance, the Canadian Forces must be capable of conducting operations in coalition with the military forces of our allies, in particular with the forces of the United States and other NATO member nations. Future Canadian surveillance systems must therefore be fully interoperable with those of our allies. This section summarizes some of the directions related to surveillance systems being considered by the United States and by NATO.

3.1 United States

In recent years, the US Department of Defense has undertaken a number of initiatives to address the development and introduction of new technologies. Some of the initiatives relevant to surveillance technology and systems are reviewed below.

3.1.1 Joint Vision 2010

Joint Vision 2010 [7] is a conceptual template developed by the US Department of Defense to "leverage technological opportunities to achieve new levels of effectiveness in joint warfighting." *Joint Vision 2010* is built upon the premise that modern and emerging technologies, particularly information-based technologies, should make possible a new level of joint and coalition capability. Underlying the

technological innovations is information superiority: the ability to collect, process and disseminate information while denying an adversary the ability to do the same.

3.1.2 New World Vistas

New World Vistas, Air and Space Power for the 21st Century [8] is a US Air Force study that attempts to identify technologies that will guarantee the air and space superiority of the United States in the next century. *New World Vistas* presents new ideas to make the future US Air Force effective, affordable, and capable in joint and multinational operations. According to *New World Vistas*, the future US Air Force will include a mix of inhabited and uninhabited aircraft, and will become efficient and effective through the use of information systems to enhance friendly operations and to confound the enemy.

New World Vistas predicts that sensors and information sources will be widely distributed. There will be sensors functioning cooperatively aboard small, distributed satellite constellations, sensors aboard Uninhabited Reconnaissance Aerial Vehicles (URAVs) and other air platforms, sensors aboard weapons, and ground-based sensors delivered by various means. The power of future information systems will lie in their ability to correlate data automatically and rapidly from many sources to form a complete picture of the operational area. While the accuracy of a single sensor and processor in identifying targets or threats might be severely limited, detection and identification probabilities can increase rapidly with appropriate sensor diversity.

3.1.3 Unmanned Aerial Vehicles

In accordance with *Joint Vision 2010* and *New World Vistas*, the (former) US Defense Airborne Reconnaissance Office (DARO), initiated funding the development of a number of different Unmanned Aerial Vehicles (UAVs) and related technologies, primarily for use in Intelligence, Surveillance, and Reconnaissance (ISR) missions. UAVs are expected to provide a sustained, responsive, and accurate picture of the battlespace. Related technologies include the Tactical Common Data Link (TCDL) to provide standardized wideband, digital, secure communication paths between multiple sensors and their users, and the Tactical Control System (TCS).

The Tactical Control System is an open-architecture system designed to facilitate interoperability with current and future systems, including the Joint Technical Architecture, the Distributed Common Ground System (DCGS) standards of the Common Imager Ground/Surface System (CIGSS), and the Defense Information Infrastructure/Common Operating Environment (DII/COE). It will provide joint warfighters with a surface-based command, control, communications and data dissemination system for UAVs.

The DND Land Forces, as part of the Unmanned Air Surveillance and Target Acquisition System (UASTAS), plans to procure a Tactical Control System to evaluate its operational effectiveness and its impact on doctrine.

3.2 NATO

The *Aerospace 2020* study [9], undertaken by the NATO Advisory Group on Aerospace Research and Development (AGARD), assesses the potential impact of emerging technologies on aerospace systems and concepts of operations to the year 2020. *Aerospace 2020* anticipates that the current trend to reduce force structures will continue. Enhanced capabilities will be essential to accommodate the demands and uncertainties posed by a wide variety of possible conflictive situations.

Aerospace 2020 states that effective decision cycles require sufficient information to be extracted quickly in a usable form for the decision-maker. The information flow must be continuous, timely, accurate and comprehensive without being overwhelming. Because information is essential to command and control of both friendly and hostile forces, all elements of the friendly system must be protected from exploitation or attack.

Aerospace 2020 predicts that the essential components of future information systems will remain as today: sensors, information processing, human-machine interface, and communications. Systems will use large numbers of small, cheap sensors instead of a small number of relatively large and expensive sensors. These systems will provide comprehensive sensor and data fusion capabilities for gathering, collating, evaluating and disseminating information, and will provide the ability to conduct information warfare and achieve information dominance.

Aerospace 2020 predicts that Unmanned Aerial Vehicles (UAVs) will continue to evolve, and will become increasingly valuable in a variety of roles, particularly Reconnaissance, Surveillance and Target Acquisition (RSTA), communications, and electronic warfare.

4.0 FUTURE SURVEILLANCE NEEDS

The Canadian Forces of the future must have capable and interoperable surveillance systems to provide planners, commanders, and warfighters with the information they will need to carry out the missions assigned to them. Some of this information will be provided by airborne surveillance systems.

This section first summarizes the objectives and expectations assigned to the Air Force by the Defence Planning Guidance, then defines the surveillance capabilities needed to support those objectives and expectations.

4.1 Objectives and Expectations

The Defence Planning Guidance assigns to the Canadian Forces objectives and expectations related to defending Canada, defending North America, and contributing to international peace and security. These objectives and expectations are not expected to change significantly over time, and as such can serve as guidance for future capability requirements. The following objectives and expectations assigned by DPG 99 [3] are relevant to surveillance capabilities.

4.1.1 Objectives Related to Defending Canada

4.1.1.1 Protect Canadian Sovereignty

Objective: The Canadian Forces are to maintain multi-purpose, combat-capable maritime, land and air forces that regularly demonstrate the capability to monitor and control Canada's territory, airspace and maritime areas of jurisdiction.

Key Results: Effective surveillance and control of Canadian territory and responding effectively to incursions.

Expectations: The Air Force is to maintain the capability to monitor and control activity in Canadian airspace and to support the Maritime Force to respond to maritime incidents and resource challenges. The Air Force is to provide assets to meet the requirements of the Maritime and Land Forces.

4.1.1.2 Assist Other Government Departments

Objective: The Canadian Forces are to assist, on a routine basis, Other Government Departments (OGDs) in achieving various national goals in areas such as fisheries protection, drug interdiction, and environmental protection.

Key Results: Cooperative agreements are established where needed; agreed levels of support are provided; and OGDs are assisted when directed.

Expectations: In conjunction with other operational elements of the Canadian Forces, the Air Force is to maintain the capability to satisfy cooperative agreements in support of Other Governments Departments, including the Department of Fisheries and Oceans, the Solicitor General, the RCMP, and Environment Canada.

4.1.1.3 Contribute to Emergency Preparedness, Humanitarian Assistance and Disaster Relief

Objective: The Canadian Forces are to contribute to humanitarian assistance and disaster relief in Canada within 24 hours, and sustain this effort for as long as necessary, and to advance civil preparedness for emergencies of all types.

Key Results: Humanitarian assistance and disaster relief requests are responded to in a manner that reduces loss of life, minimizes human suffering, and limits property and environmental damage; also, foster and coordinate civil preparedness and response activities to ensure a national capability and uniform standard of emergency services.

Expectations: The Air Force is to maintain the capability to respond to natural and man-made disasters, such as earthquakes, floods and fires. This response is to include assisting civil authorities in providing relief of human suffering and re-establishing local infrastructure.

4.1.1.4 Provide Search and Rescue

Objective: Maintain a national search and rescue capability.

Key Results: Search and rescue incidents are responded to in a manner that minimizes loss of life and suffering.

Expectations: The Air Force is to maintain the capability to respond to national search and rescue incidents such as an airline crash or the sinking of a ship. The response is to be undertaken in conjunction with other operational elements of the Canadian Forces as well as the Civil Air Search and Rescue Association and the Coast Guard.

4.1.1.5 Respond to Terrorist Incidents

Objective: Maintain a capability to assist in mounting, at any time, an immediate and effective response to terrorist incidents.

Key Results: Terrorist incidents are responded to in a manner that meets the requirements of the Solicitor General and the Government of Canada.

Expectations: The Air Force is to maintain the capability of supporting a response to terrorist incidents in conjunction with other operational elements of the Canadian Forces. This response is to include forces (including aviation specialist capabilities for hostage rescue response), infrastructure, and a Command and Control capability.

4.1.1.6 Provide Aid to the Civil Power

Objective: Respond to requests for aid of the civil power and sustain this response for as long as necessary.

Key Results: Effective aid is provided to civil authorities upon their request.

Expectations: The Air Force is to generate air mobility support to other Canadian Forces operational forces.

4.1.2 Objectives Related to Defending North America

4.1.2.1 Interoperability with US Military Forces

Objective: Maintain the ability to operate effectively at sea, on land, in the air, and in space with the military forces of the United States in defending the northern half of the Western Hemisphere.

Key Results: Effective interoperability with US Forces. Treaty and other obligations are met so that threats to North America are detected and resolved.

Expectations: The Air Force is to be capable of responding with all available air assets for the defence of North American airspace within the timeframe dictated by the strategic situation. These air assets must be effectively interoperable with US assets.

4.1.3 Objectives Related to Contributing to International Peace and Security

4.1.3.1 Protect and Evacuate Canadians Abroad

Objective: Maintain the capability to assist the Department of Foreign Affairs and International Trade (DFAIT) in the protection and evacuation of Canadians from areas threatened by imminent conflict.

Key Results: Requests by DFAIT for the protection and evacuation of Canadians are responded to in a manner commensurate with the particular situation, resulting in the safe recovery of affected Canadians.

Expectations: The Air Force is to maintain the capability to assist in an evacuation of Canadians from areas threatened by imminent conflict. This assistance could be provided in conjunction with other elements of the Canadian Forces and the military forces of other nations. The role of the Air Force is to provide air evacuation.

4.1.3.2 Participate in Multilateral Operations

Objective: Participate in multilateral operations anywhere in the world under United Nations auspices, within a coalition of like-minded nations, or in the defence of a NATO member state.

Key Results: UN and international commitments and government directives to respond to international contingencies (including preventive deployment, peacekeeping, peace-enforcement, post-conflict peace building and measures to enhance stability and build confidence) are met. A threat against NATO nations is deterred or successfully countered. Canada's NATO commitments for military forces are met.

This objective has several expectations, which are described below.

4.1.3.2.1 Peace Support Operations (Chapter 6 of the UN Charter)

Expectations: The Air Force is to maintain the capability to operate in low-level operations as part of a multi-national coalition force enforcing UN no-fly zones and providing air mobility operations anywhere in the world.

4.1.3.2.2 Peace Support Operations (Chapter 7 of the UN Charter)

Expectations: The Air Force is to maintain the capability to operate as part of a multi-national coalition UN force in mid-level joint and combined operations. Air Force assets are to be able to operate against modern enemy forces anywhere in the world.

4.1.3.2.3 NATO Collective Defence

Expectations: The Air Force is to maintain the capability to conduct mid-level joint and combined operations throughout the NATO area of interest.

4.1.3.2.4 International Humanitarian Assistance and Disaster Relief

Expectations: The Air Force is to maintain the capability to operate as part of an international joint and combined force in providing humanitarian assistance in concert with non-governmental organizations. The Air Force is to provide assistance in a low threat environment anywhere in the world.

4.2 Surveillance Capabilities to Support Objectives

Table 4-1 associates the objectives given in the previous section with specific Force Planning Scenarios, and defines the surveillance capabilities to support each objective and scenario. The different generic surveillance capabilities are described in more detail in the following subsections.

Table 4-1 Objectives, Force Planning Scenarios, and Surveillance Capabilities

Objective	Force Planning Scenario	Surveillance Capabilities
Protect Canadian Sovereignty	(Scenario 4) Surveillance and Control of Canadian Territory and Approaches	Maritime Surveillance Land Surveillance Airspace Surveillance Space Surveillance
Assist Other Government Departments	(Scenario 8) National Sovereignty and Interests Enforcement	Maritime Surveillance Land Surveillance Airspace Surveillance
Contribute to Emergency Preparedness, Humanitarian Assistance and Disaster Relief	(Scenario 2) Disaster Relief in Canada	Maritime Surveillance Land Surveillance
Provide Search and Rescue	(Scenario 1) Search and Rescue in Canada	Maritime Surveillance Land Surveillance
Respond to Terrorist Incidents	(Scenario 7) Aid of the Civil Power	Maritime Surveillance Land Surveillance
Provide Aid to the Civil Power	(Scenario 7) Aid of the Civil Power	Land Surveillance
Interoperability with US Military Forces	(Scenario 10) Defence of Canadian and US Territory (Scenario 11) Collective Defence	Interoperability with US Systems Maritime Surveillance Land Surveillance Airspace Surveillance
Protect and Evacuate Canadians Abroad	(Scenario 5) Evacuation of Canadians Overseas	Land Surveillance
Peace Support Operations (Chapter 6 of the UN Charter)	(Scenario 6) Peace Support Operations (UN Chapter 6)	Interoperability with UN Systems Maritime Surveillance Land Surveillance Airspace Surveillance
Peace Support Operations (Chapter 7 of the UN Charter)	(Scenario 9) Peace Support Operations (UN Chapter 7)	Interoperability with UN Systems Maritime Surveillance Land Surveillance Airspace Surveillance
NATO Collective Defence	(Scenario 11) Collective Defence	Interoperability with NATO Systems Maritime Surveillance Land Surveillance Airspace Surveillance
International Humanitarian Assistance and Disaster Relief	(Scenario 3) International Humanitarian Assistance	Land Surveillance

4.2.1 Maritime Surveillance

The Canadian Forces will need maritime surveillance capabilities to support the objectives and scenarios outlined in Table 4-1. This includes the detection, tracking, and identification of targets in the Inner, Middle, and Outer Maritime Surveillance Zones (shown in Figure 4-1) of the Atlantic, Pacific, and Arctic areas of Canadian maritime responsibility, and in support of out-of-area operations. Potential targets include surface vessels, sub-surface vessels, ice, mines, Emergency Locator Transmitters (ELTs), downed aircraft, oil spills, algal blooms, debris, and dumped waste. Information regarding weather, sea-state, and surface currents are also part of a complete maritime surveillance capability.

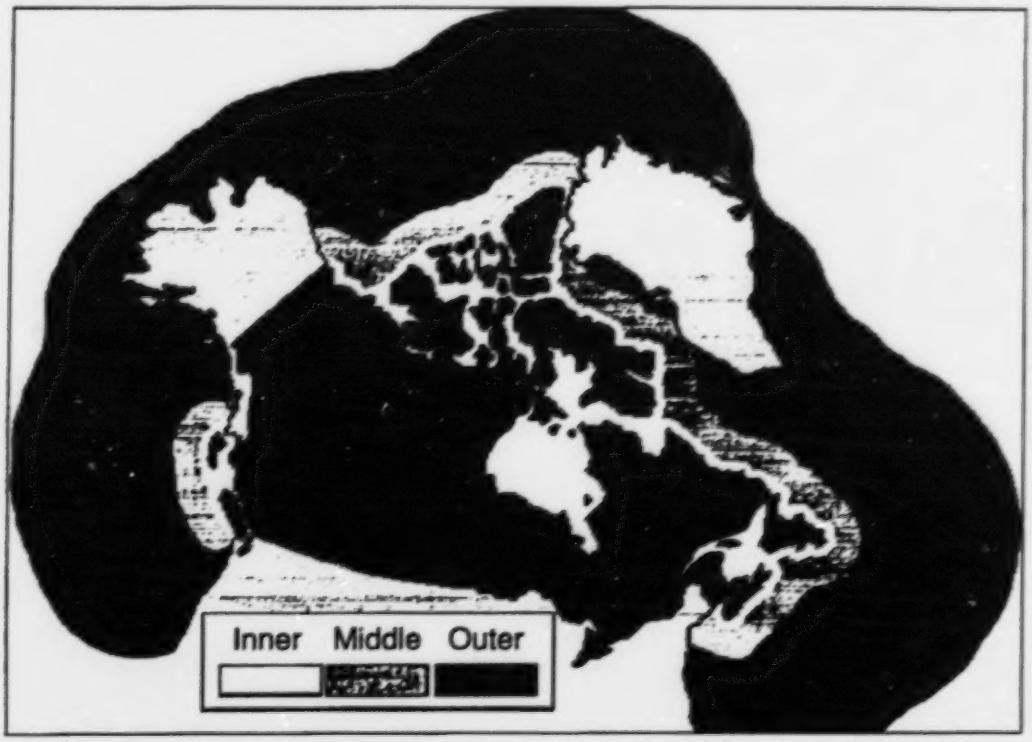

Figure 4-1. Maritime Surveillance Zones: the Inner Zone (30 nautical miles), the Middle Zone (250 nautical miles), and the Outer Zone (1000 nautical miles).

Note that this figure is not authoritative; it is for illustrative purposes only.

4.2.2 Land Surveillance

The Canadian Forces will need land surveillance capabilities to support the objectives and scenarios outlined in Table 4-1. This includes domestic surveillance to support missions to aid the civil power, and surveillance in support of out-of-area operations. Potential targets include personnel concentrations, ground vehicles, convoys, downed aircraft, minefields, obstacles to mobility, NBC hazards, flooded areas, bridges, landing strips, and bunkers.

4.2.3 Airspace Surveillance

The Canadian Forces will need airspace surveillance capabilities to support the objectives and scenarios outlined in Table 4-1. This includes surveillance of Canadian airspace and surveillance in support of out-of-area operations. Potential targets include manned aircraft, unmanned aircraft, and missiles.

4.2.4 Space Surveillance

As Canada deploys more assets in space, the Canadian Forces will need space surveillance capabilities to support the objectives and scenarios outlined in Table 4-1. This includes detecting and tracking threats to Canadian assets in space and threats to Canada from or through space. Potential targets include satellites, missiles, and space debris.

4.2.5 Interoperability with Other Military Forces

The Canadian Forces will need surveillance systems that are fully interoperable with those of the United States to support missions in defence of Canadian and US territory. Interoperability with the military forces of NATO and UN nations is needed for the successful conduct collective defence and peace support operations.

5.0 CONCEPT AIRBORNE SURVEILLANCE SYSTEM

The ideal surveillance system, airborne or otherwise, would have the following attributes:

- the ability to detect, classify, identify, locate, and track all targets of interest in all areas of interest;
- the ability to operate continuously in all weather conditions, day or night;
- the ability to interchange data securely and reliably;
- interoperability with US and other allied surveillance systems;
- the ability to be deployed when and where required; and
- the ability to operate covertly when necessary.

The ideal surveillance system would thus be able to provide all users of surveillance products with all the surveillance information they need all the time, on time, in a meaningful and useful form, and at an affordable cost. Depending on the mission, airborne surveillance systems can be used to provide a substantial subset of the needed surveillance information. This section outlines a concept airborne surveillance system to provide some of the surveillance capabilities identified in the previous section.

5.1 Assumptions

Given the long time required to develop and field new military systems, it is assumed that any surveillance systems in service about the year 2010 will be based on technologies that are either available currently or are now under development.

It is assumed that the mix of airborne platforms in 2010 will not be much different from those currently available, with perhaps the addition of a small number of medium and long range Unmanned Aerial Vehicles (UAVs) to support tactical land force surveillance and wide area surveillance, respectively.

5.2 Concept Overview

The overall system concept, shown schematically below in Figure 5-1, is that of a network of sources of surveillance information (groups of sensors on individual surveillance platforms), users of surveillance

information (planners, commanders, warfighters, intelligence, etc.), and disseminators of surveillance information (command and control systems). Sources and users will be connected to disseminators through secure, high-speed, data links.

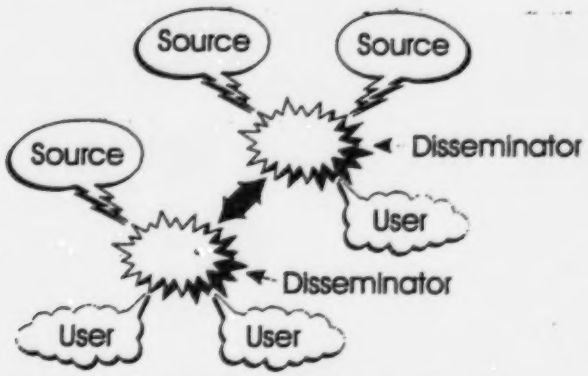

Figure 5-1. Concept Airborne Surveillance System

Sources will transmit their surveillance information to disseminators. Users will be able to retrieve surveillance information from disseminators (information pull), and disseminators will be able to initiate the transfer of information to users (information push). Intelligent assistant software will ensure that users will be aware of and have access to all pertinent and available surveillance information.

5.3 Surveillance Sources

A surveillance source is a group of surveillance sensors on a platform. The surveillance sensors will include electro-optic (EO), infrared (IR), radio frequency (RF), magnetic, and acoustic sensors. The platform may be manned or unmanned, fixed or rotary wing. The platform may simultaneously be a user of surveillance information.

Processors on the platform will automatically interpret and integrate the sensor data and extract target information to form the surveillance information for that platform. The surveillance information will be available locally on the platform and will also be transmitted to the nearest surveillance disseminator, which might be on the land, on the sea, in the air, or in space.

Many of these surveillance sensors will produce high-resolution imagery. The use of multiple sensors with different resolutions and operating at different wavelengths will greatly enhance the ability to detect and classify targets in all weather conditions, and will reduce the effectiveness of concealment attempts.

5.4 Surveillance Users

Users of surveillance information will potentially have access to all available surveillance information. Users will have advanced graphical displays and human-machine interfaces to facilitate the effective integration and interpretation of the surveillance information. Intelligent assistant software will help the human operator locate and acquire the most meaningful and appropriate surveillance information products, and users will be able to request the acquisition of specific surveillance information products.

5.5 Surveillance Disseminators

Surveillance disseminators will collect the information provided by surveillance sources. Disseminators will also have access to centrally maintained *a priori* databases (charts, intelligence, etc.) to provide the ancillary information necessary to realize the full potential of the surveillance system anywhere in the world. Disseminators will enhance the value of the surveillance information products by integrating the real-time information from multiple surveillance sources with the *a priori* database information.

All surveillance sources and surveillance users will be connected to disseminators, which in turn will be interconnected to form a network of disseminators. Disseminators will be able to notify users of the availability of surveillance products (information push), and will be able to provide users with requested information (information pull). Surveillance information will be pulled or pushed according to rules that can depend, for example, on the class of surveillance user, location, time, or type of target. Disseminators will be able to accept user requests for specific surveillance products, cueing or deploying surveillance resources as appropriate to acquire those products.

5.6 Example Use of the Concept Surveillance System

As an example of the use of the concept surveillance system, consider a situation based on Force Planning Scenario 10 (Defence of Canada and US Territory). While the likelihood of occurrence of Scenario 10 is low, mission success is critical. A similar, though less critical situation, could be based on Scenario 4 (Surveillance and Control of Canadian Territory and Approaches).

The situation described below illustrates the following features of the concept surveillance system: the connectivity of surveillance sources, users, and disseminators; the use of intelligent software assistants; information push and information pull; and the tasking of surveillance resources by users.

5.6.1 Summary of Force Planning Scenario 10

In Force Planning Scenario 10, Canada and the US are part of a coalition operation to restore the territorial integrity of an invaded nation. Intelligence assessments have determined that the aggressor nation may undertake threatening action against Canada and the US to foster national support and to demonstrate its military might and the vulnerability of the North American coalition partners.

The aggressor controls an effective military force that is capable of carrying out an attack on North America. The aggressor possesses nuclear and chemical weapons and delivery platforms. An attack could range from instigating or funding internal discontent to repeated incursions into sovereign territory by aircraft, surface vessels, or sub-surface vessels.

The Canadian Forces would conduct surveillance of air and maritime approaches to North America. The CF would attempt to detect, identify, and intercept the hostile vessel or aircraft before it arrives within attack range of North America.

5.6.2 Example Scenario

A NATO nation has been invaded by its neighbour after the discovery of natural resources in a long-disputed border territory. The invading forces have established control over a significant area before being stopped. Canada has joined a coalition force with the US and other NATO countries to expel the aggressor and re-establish control of the invaded territory.

In retaliation for Canadian participation in the coalition, the aggressor has decided to attack Canada. Intelligence sources have discovered that the aggressor plans to damage the Canadian economy by using chemical agents to destroy fish stocks off the coast of Nova Scotia. The aggressor's navy is known to have the capability to launch chemical weapons.

Trinity, the IUSS naval ocean surveillance facility in Halifax, has detected two suspicious vessels approaching the Middle Maritime Surveillance Zone from southeast of the Grand Banks. One vessel has been classified as one of the aggressor's X-Class destroyers; the other vessel is probably one of the aggressor's new Y-Class submarines. Unfortunately, Trinity has lost its contact with both vessels.

A Canadian Patrol Frigate (CPF) has been tasked to leave its patrol area southeast of Sable Island to intercept the aggressor's destroyer and to confirm the classification of the probable submarine. A Maritime Patrol Aircraft (MPA) returning from a routine Arctic mission has been directed to lend assistance to the CPF.

The CPF is both a source and a user of surveillance information; it is connected via satellite link to a land-based surveillance disseminator near Halifax. Like the CPF, the MPA is both a source and user of surveillance information. The MPA is connected via radio link to a surveillance disseminator on a long-range UAV, which is in turn connected to the surveillance disseminator in Halifax. Figure 5-2 shows the locations of the CF and aggressor assets for this scenario. The communications linkages are denoted in the figure by white "lightning bolts".

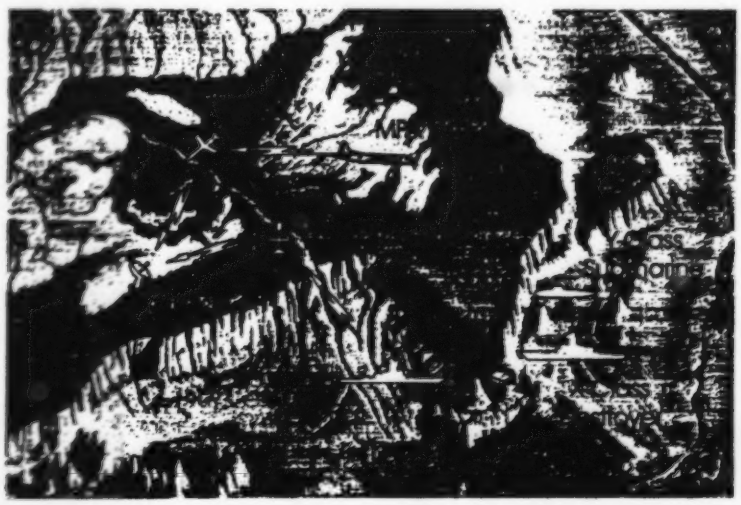

Figure 5-2. Locations of CF assets (white) and aggressor assets (grey).

The sonar operator on the CPF detects and locates the aggressor's X-Class destroyer. The probable submarine is detected and located approximately; precise location and classification are not possible due to interference from fishing activity on the Tail of the Banks.

The surveillance system on the MPA automatically notifies its surveillance disseminator that the MPA is entering the area of interest, and that it has available surveillance assets that include a maritime search radar with a Spotlight SAR mode, an ESM receiver, and sonobuoys. The information about the

availability and capabilities of the new surveillance source is automatically broadcast to all surveillance users in the area, including the CPF.

The intelligent assistant on the CPF alerts the commander of the availability of the MPA and its surveillance assets. The intelligent assistant suggests that the MPA could be tasked to confirm the classification of the X-Class destroyer and to classify and locate the Y-Class submarine. The commander concurs with the suggestion, and authorizes the intelligent assistant to initiate the MPA tasking. The tasking request is authenticated and approved by the disseminator near Halifax, which forwards the tasking to the MPA for execution.

In response to the tasking, and using the automatically provided sonar contact coordinates, the MPA changes course toward the location of the X-Class destroyer. The radar's search mode is used to scan the area and locates a target, which appears to be a surface vessel. The ESM indicates that there are no transmitting radars in the target area, suggesting that the target is operating in radar silence. Cued by the search mode, the Spotlight SAR mode is used to image the target, resulting in the positive identification of the target as an X-Class destroyer. All known information about the destroyer is sent automatically to the surveillance disseminator, which forwards the information to the CPF. Given the precise location and confirmed classification of the destroyer, the CPF commander is able to initiate procedures to intercept.

When within range of the probable Y-Class submarine, the radar's search mode is again used to scan the area of interest. This time, two small targets are located. The ESM identifies one target as a fishing boat; the second target appears to be the snorkel of a submarine. The Spotlight SAR mode is used to image the area, and confirms the presence of the fishing boat. A field of sonobuoys is deployed in the area around the second radar target, and confirms that the target is a Y-Class submarine. All known information about the submarine is sent automatically to the surveillance disseminator, which again forwards the information to the CPF. Given the location and confirmed classification of the submarine, the CPF commander is able to initiate the appropriate action.

6.0 ROLE OF THE DEFENCE R&D BRANCH

This section discusses the potential role of the Defence Research and Development Branch (DRDB) in helping the Canadian Forces, particularly the Air Force, realize the objectives of the concept airborne surveillance system.

In general terms, the role of DRDB is to provide DND with scientific and technology expertise to make the best use of technology as well as to anticipate technological developments [3]. Science and technology (S&T) support is provided, in part, through the exploration and development of new concepts and equipment, the assessment and exploitation of key technologies through international and national collaboration, and the assessment of foreign technology derived from military intelligence.

DRDB has the ability to construct advanced concept technology demonstrators, and maintains expertise that can be provided during requirement assessment and procurement activities. Concept technology demonstrators can be used to show potential future capabilities and involve operation personnel in the development cycle to ensure useful products.

The following sub-sections discuss more specific roles of DRDB with respect to the realization of future surveillance systems. These roles are placed in context with the overall roles of DRDB in [10].

6.1 Communication, Command, Control and Information Systems

The surveillance disseminators discussed in Section 5.5 above would functionally be part of the overall Communication, Command, Control and Information (C^3I) system. DRDB can provide S&T support in the areas of interoperability and data links.

6.1.1 Interoperability

Existing surveillance resources and C^3I systems may have incompatible communications interfaces and requirements. To realize the objectives of the concept surveillance system, it will be necessary to remove the so-called "stovepipes" from existing components, to ensure that new components are able to communicate with one another, and to ensure that airborne surveillance systems are interoperable with other surveillance systems.

DRDB can help to determine the best solution to the existing inter-communications problems, and can help determine which standards to adopt to enhance interoperability. DRDB can monitor similar initiatives in allied countries to enhance interoperability with our allies.

6.1.2 Data links

Surveillance sources, users, and disseminators will be interconnected via high-speed communications links to permit the real-time transfer of large quantities of data. Data fusion and data processing techniques will help reduce the data capacity requirements. There will, however, be a need to increase data capacity beyond what is currently available.

DRDB will continue, in conjunction with the Communications Research Centre (CRC), to develop more capable and more secure data links to support future requirements. DRDB can also monitor similar initiatives underway in allied countries.

6.2 Surveillance and Target Acquisition Technologies

The performance of the concept surveillance system will depend upon the performance of the surveillance platforms, the performance of individual surveillance sensors, deployment tactics, the ability to fuse data from multiple sensors, and the ability to extract target features from the fused data. DRDB can provide support and assistance in all of these areas.

6.2.1 Sensors

DRDB will continue to develop more capable surveillance sensors using electro-optics, infrared, and radio frequency technologies.

6.2.2 Multi-sensor fusion

The concept surveillance system will combine real-time data from multiple sensors on one platform and across multiple platforms. The real-time data will be augmented with *a priori* information stored in large databases. For example, a database of target models, geophysical models, terrain data, and intelligence would be used to help with change detection and target recognition.

DRDB can help develop techniques and algorithms to realize the data fusion functionality within the concept surveillance system.

6.2.3 Information processing

The concept surveillance system will implement automatic target recognition and feature extraction to reduce the burden on the human operator and to reduce data transfer requirements.

DRDB can help develop techniques and algorithms to realize the target recognition and feature extraction functionality within the concept surveillance system. This would include target modelling and phenomenology studies, as well as development of signal and image processing algorithms. DRDB can also monitor similar initiatives underway in allied countries.

6.3 Information Operations

The operation of the concept surveillance system depends upon the transfer of surveillance information among surveillance sources, users, and disseminators. This information transfer presents a target for compromise by an adversary. Unfriendly activities include interfering with the communication link to reduce the capacity of the channel (jamming), and providing false information with the intent to degrade performance or create confusion (spoofing).

DRDB can help develop techniques to ensure the integrity of the communication link. DRDB can also monitor similar initiatives underway in allied countries.

6.4 Human Factors

The surveillance user of the future will have access to a bewildering quantity of surveillance information. Without adequate human-machine interfaces and user training, the surveillance user might well become overwhelmed and fail to perform at an acceptable level.

DRDB can help develop advanced human-machine interfaces and training programs to aid the surveillance user to digest and assimilate the large quantity of available information. DRDB can also monitor similar initiatives underway in allied countries.

6.5 Technological Change

Recent advances in commercially available hardware and software technologies will have a significant impact on the affordability and longevity of future systems. Maintaining a leading edge capability with system components becoming obsolete at varying rates requires a streamlined procurement cycle and evolutionary updates to installed systems. Systems will have to be developed, purchased, and maintained with the intention of incremental updates of sensors, processors, and software as new generations of these technologies become available. DRDB can monitor the advances of technology and advise the Canadian Forces regarding their applicability.

7.0 FUTURE WORK

This Technical Memorandum is an interim report for the *Airborne Surveillance Concepts 2010* project. Future work will include consultation with client groups in the Canadian Forces to validate the future surveillance needs presented in Section 4.0 and to enhance the capabilities of the concept surveillance system developed in Section 5.0. Consultation within the Defence Research and Development Branch will further define the role of the Branch in satisfying these future needs and in realizing the objectives of the concept surveillance system.

8.0 SUMMARY AND CONCLUSIONS

This report reviews the missions assigned to the Canadian Forces by the Defence Planning Guidance, and discusses the future surveillance needs required to support those missions. A concept airborne surveillance system is presented to satisfy the future surveillance needs. The role of the Defence Research and Development Branch is discussed with respect to activities to satisfy these future needs and to realize the objectives of the concept surveillance system.

Future work will include consultation with the Canadian Forces to validate the future surveillance needs and to enhance the capabilities of the concept surveillance system. Consultation within the Defence Research and Development Branch will further define the role of the Branch in this activity.

GLOSSARY

Aerospace Surveillance and Reconnaissance	Aerospace surveillance and reconnaissance operations involve the collection of information on the resources and activities of an enemy or potential enemy by airborne, ground-based, and space-based sensors.
Capability	The state of having sufficient power, skills and ability to carry out a military activity or operation.
Coalition	An ad hoc agreement between two or more sovereign nations for a common action.
Combined	An adjective that connotes activities, operations, organizations, etc between two or more forces or agencies of two or more allies. *See also joint*
Command, Control and Information System	An integrated system comprised of doctrine, procedures, organizational structure, personnel, equipment facilities and communications which provides authorities at all levels with timely and adequate data to plan, direct, and control their activities.
Concept	A notion or statement of an idea, expressing how something might be done or accomplished, that may lead to an accepted procedure.
Concept of Operations	A clear and concise statement of the line of action chosen by a commander in order to accomplish his mission.
Doctrine	Fundamental principles by which the military forces guide their actions in support of objectives. It is authoritative but requires judgement in application.
Joint	An adjective that connotes activities, operations, organizations, etc in which elements of more than one service of the same nation participate. *See also combined*
Peacekeeping	The prevention, containment, moderation and termination of hostilities between or within states through an impartial third-party intervention organized and directed internationally for restoring and maintaining peace. This is conducted using military forces, police and civilians and usually with the consent of the main belligerents.
Peacemaking	The process of resolving disputes that could lead to conflict, primarily through diplomacy, mediation, negotiation or other forms of peaceful settlement.
Scenario	An outline of a planned series of events (real or imagined) that includes specifications as to the various scenes and situations, the cast of characters and detailed direction for the stage setting and the development of the events.

Sovereignty	A difficult and complex concept, sovereignty comprises both emotional and rational components and is often a matter of perception. It relates to the state's monopoly on the use of force within its territory and is tied to the recognition of a political body as a state. Implicit within the concept of sovereignty is the ability of the state to be aware of and control activity within its borders.
Supporting Air Operations	Those non-combat air operations which enhance the combat capability of other air, land, and maritime forces.
Surveillance	The systematic observation of aerospace, surface and sub-surface areas, places, persons or things by visual, aural, photographic, electronic, or other means.

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